CLAIMS

1. A method for calibrating parameters of sensor elements in a sensor array, comprising:
receiving an output signal of at least two sensor elements signal in reaction to an input signal from a signal source;
estimating a cross-correlation between the output signals of at least two of said sensor elements;
optimising a difference between the estimated cross-correlation and a cross-correlation model; and thereby estimating said parameters from the optimised difference;
wherein a cross-correlation model is used as represented by the mathematical equation:

$$\boldsymbol{R} = \boldsymbol{G}\,\boldsymbol{B}\,\boldsymbol{G}^{\mathrm{H}} + \boldsymbol{D}$$

in which equation:
$\boldsymbol{R}$ represents a cross-correlation matrix,
$\boldsymbol{G}$ represent a gain matrix comprising gain parameters,
$\boldsymbol{G}^{H}$ represents the Hermitian conjugate of the gain matrix,
$\boldsymbol{D}$ represents a ((block) diagonal) noise matrix comprising noise parameters and
$\boldsymbol{B}$ represents a matrix comprising information about the signal source.

2. A method as claimed in claim 1, wherein said difference is a least square difference.

3. A method as claimed in claim 1 or 2, wherein the cross-correlation is obtained by determining a time-averaged covariance matrix from the output signals.

4. A method as claimed in any one of the preceding claims, wherein the sensor array is a single polarization or non-polarized sensor array.

5. A method as claimed in claim, wherein the sensor elements are dual polarization sensor elements for receiving a dual polarised signal.

6. A method as claimed in any one of the preceding claims, wherein said method is performed for output signals of the sensor elements generated in reaction to input signals from at least three signal sources with different polarizations.

7. A method as claimed in claim 4, wherein said optimising comprises: minimising a difference between a weighted logarithm of the estimated cross-correlation and a weighted logarithm of the cross-correlation and estimating the gain of at least one of the sensor elements from said difference.

8. A method as claimed in claim 7, wherein the logarithm is weighted by a weighting matrix with matrix values relating to said gain parameters.

9. A method as claimed in claims 7 or 8, wherein said optimising and said estimating gain parameters are performed at least a first time and a second time, wherein in the first time an uniform weight is used for all output signals and in the second time the weight is used in dependence on the gain estimated in the first time for the respective output signals.

10. A method as claimed in any one of claims 7-11, wherein said optimising comprises an operation as represented by the mathematical equation:

$$\{\mathbf{g}_{est}\} = \operatorname{argmin}_{\mathbf{g},\mathbf{k}} (\| \mathbf{W}\,\mathbf{J}\,\mathrm{vec}(\ln(\mathbf{R}_{est}) - \ln(\mathbf{g}\,\mathbf{g}^{H}) + 2\pi \mathbf{k} i) \|_{F})^2$$

, in which equation:

$\mathbf{g}_{est}$ represents the parameter to be estimated;

$\mathbf{g}$ represents a variable

$\mathbf{g}^H$ represents the Hermitian conjugate of the variable

$\mathbf{J}$ represent a selection matrix which puts zeros on the main diagonal;

$\mathbf{k}$ represents a phase unwrapping vector containing integer values.

$\mathbf{W}$ represents a weighting matrix; and

$\mathbf{R}_{est}$ represents the estimated cross-correlation.

11. A method as claimed in any one of the preceding claims, wherein the signal source is a satellite in orbit around a celestial body.

12. A method as claimed in any one of the preceding claims, wherein the signal source is a pulsar.

13. A method as claimed in any one of the preceding claims, wherein the output signals have a low signal to noise ratio.

14. A method as claimed in any one of the preceding claims, wherein the sensor elements are antennas in a phased array antenna.

15. A method as claimed in any one of the preceding claims, wherein the sensor elements are electro-magnetic sensors elements.

16. A method as claimed in any one of the preceding claims1, wherein the sensor elements are acoustical sensor elements.

17. A calibration system for calibrating parameters of sensor elements in a sensor array , comprising

at least two inputs, each connectable to an output of an sensor element in a sensor array;

a correlation estimator device for estimating a correlation between the output signals of at least two of said sensor elements

an optimiser device for optimising a difference between the estimated cross-correlation and a cross-correlation model and thereby estimating said parameters from the optimised difference;

a memory device containing the cross-correlation model, which model is represented by the mathematical equation:

$$\boldsymbol{R} = \boldsymbol{G}\,\boldsymbol{B}\,\boldsymbol{G}^{H} + \boldsymbol{D}$$

in which equation:

$\boldsymbol{R}$ represents a cross-correlation matrix,

$\boldsymbol{G}$ represent a gain matrix comprising gain parameters,
$\boldsymbol{G^H}$ represents the Hermitian conjugate of the gain matrix,
$\boldsymbol{D}$ represents a noise matrix comprising noise parameters and
$\boldsymbol{B}$ represents a matrix comprising information about the signal source and .

18. A calibration system as claimed in claim 17, wherein the sensor array is a dual polarised sensor array

19. A calibration system as claimed in claim 17, wherein the sensor array is a single polarization or non-polarized sensor array.

20. An array signal processing system calibrated with a method as claimed in any one of claims 1-17

21. A computer program product, comprising program code for performing steps of a method as claimed in any one of claims 1-17 when run on a programmable device.

22. A data carrier comprising data representing a computer program product as claimed in claim 21.